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| **Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.** [Clarification Statement: Emphasis is on how processes change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.] |  |



**Big Quake Is Latest in Cluster That Began in '04**

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| **Map of 10 Largest Earthquakes Since 1900** |

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*By Carolyn Y. Johnson*

The massive earthquake that shook Japan yesterday, creating a destructive tsunami, is the latest in a series of especially fierce temblors since 2004 - after four decades without such large quakes.

No one knows, however, if the recent run of extreme earthquakes - including the 9.1 magnitude earthquake in the Indian Ocean in 2004 and last year's 8.8 magnitude earthquake off the coast of Chile - portends more large earthquakes around the Pacific Rim in the near future, because there is no way to predict exactly where, when, and how big an earthquake will be.

There was a cluster of extremely large earthquakes from 1946 to 1964, a period that ended with the 9.2 magnitude Alaskan earthquake, the second largest since 1900.

Now, after 40 years of less powerful seismic activity, there have been a dozen earthquakes of 8.0 magnitude or greater. Yesterday's 8.9 magnitude earthquake was the fifth strongest since 1900.

That might seem like a powerful trend, but geophysicists do not know whether the clustering of large earthquakes represents anything more than chance.

"This period absolutely seems anomalous, and there appears to be at least one other time period in history . . . of very large earthquakes," said Colleen Dalton, a seismologist and earth sciences professor at Boston University, referring to the mid-20th century cluster. "But without more data, I'm not sure we can say if it's more than just a coincidence."

John Ebel, director of Boston College's Weston Observatory, noted that seismically, the current period seemed to resemble the cluster of large earthquakes in the middle of the last century.

"Is there something within the Earth that might be preferentially triggering these large earthquakes? We don't know," Ebel said. "But that's certainly something that is important and interesting to look at from a scientific perspective."

The earthquake's power came as a surprise to many in the seismological community. It struck 80 miles off the east coast the Japanese island of Honshu, where one tectonic **plate** is diving underneath another. This is different than the type of earthquake that would occur along the San Andreas fault in California, when two plates are moving in opposite directions in the same plane. The Japan quake is the same type as the one that hit Chile in 2010.

Such quakes occur after tectonic stresses build up for years and the plates abruptly slip. Dalton said early analysis suggests that in spots, the plates may have slipped more than 50 feet.

The threat of earthquakes are not new to the area - the US Geological Survey reported that the Japan trench has had nine earthquakes of 7 magnitude or greater since 1973.

Still, Brian Atwater, a USGS geologist, said that in recent history nothing of this magnitude had occurred in the area.

"There's nothing in Japanese written history for this area since 869 that looks like this," Atwater said. "I think a lot of scientists worldwide wondered whether this particular subduction zone - the Japan trench, the southern part - could ever produce a great earthquake."

Atwater said geologists have found evidence of sand deposited in this part of Japan due to past tsunamis, hints that before modern instrumentation had been developed the area had sustained major earthquakes.

Jerome Hajjar, chair of civil and environmental engineering at Northeastern University, engineers structures that can withstand earthquakes and has worked in Japan.

He said Japanese engineers are leaders in both researching earthquake engineering problems and in implementing measures to increase the integrity of infrastructure.

Still, he said, "most structures, even if they're new, might have significant damage to them in a major earthquake like this. They're not designed not to be damaged; they're designed not to collapse."

The earthquake was preceded by foreshocks, including a 7.2 magnitude earthquake that occurred two days earlier, about 25 miles away.

Although there have been attempts to predict earthquakes over the years, it is not possible to get a precise seismic forecast. Seismologists know where faults are, and can assess earthquake risk, but predicting specific quakes ahead of time has been an elusive goal. Not all massive earthquakes give warning shots like foreshocks, and even when they do, those may only be identified as precursors to something bigger in hindsight.

At the Pacific Tsunami Warning Center, David Walsh, an oceanographer, said the earthquake created a 23-foot-high tsunami in Japan. Other reports said waves reached as high as 30 feet in Japan.

The tsunami may even register slightly on tide gauges off the coast of New England, scientists said, as the waves make their way around the tip of South America and into the Atlantic.

"Ultimately, it's like one big bathtub," said Uri ten Brink, a USGS scientist at the Woods Hole Field Center. "All around the world you see something."

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**Summary:**

 "The massive earthquake that shook Japan yesterday, creating a destructive tsunami, is the latest in a series of especially fierce temblors since 2004--after four decades without such large quakes." ***(Boston Globe)*** This article discusses the increased number of severe earthquakes since 2004, in light of the devastating 9.0 earthquake that struck Japan on March 11, 2011.

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1.) According to the text, what natural disaster caused the tsunami in Japan?

2.) Using information from the text, how is the tectonic plate near Japan, different from the one in California?

3.) According to the text, what evidence do geologists have to prove that tsunami’s have occurred here in the past?

4.) Use evidence from the text to support or deny the claim that the public had advanced warning about the earthquake.